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STRUCTURED LEARNING AND TRAINING ENVIRONMENTS IN SOIL SCIENCE. PROJECT REPORT.

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Study carrels, tape recorders, slide projectors, and other materials were used to create structured learning and training environments (SLATEs) that individualized study situations for a university soil sciences course. Four lectures and a two hour laboratory each week were replaced by one lecture, one discussion or quiz period, and a three to four hour SLATE program. A workbook was developed that coordinated all the learning tasks in chronological order for each SLATE unit. This study procedure saved time and permitted students to review notes while they were using slides and equipment. Cost of a carrel station without services or scientific equipment averaged $555. Students' attitudes, indicated on brief questionnaires distributed at the conclusion of the course, were favorable. (JO)

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Structured Learning and Training Environments in Soil Science

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One approach to the problem of improving and individualizing instruction is the creation of multi-media independent study situations. At Michigan State over the past few years, a number of Structured Learning and Training Environments (SLATEs) have been developed. In the summer of 1966, study carrels, tape players, slide projectors, and duplicate materials were made available by the Educational Development Program[2] for the development of a SLATE for Soil Science 210, "Fundamentals of Soil Science." This document describes the pilot multi-media program developed for Soil Science.

Program and Facilities

A five credit introductory course, Soil Science 210, with four lectures and a two-hour lab per week was changed to one lecture, one discussion or quiz period, and a three - four hour SLATE program per week. The new program was first used in the fall of 1966 with a limited enrollment of 76 and in the spring of 1967 with 213 students. The SLATE laboratory (Figure 1) involved the four kinds of activities shown in Figure 2.

SLATE units used during the spring term of 1967 are listed in Table 1. Each unit provided approximately two hours of instruction. The entire course content was presented as SLATE units. Fourteen units have been developed to date and about three more are planned for the future. Lecture time was used for testing, coordination, motivation, and special programs, including films and guest lecturers.

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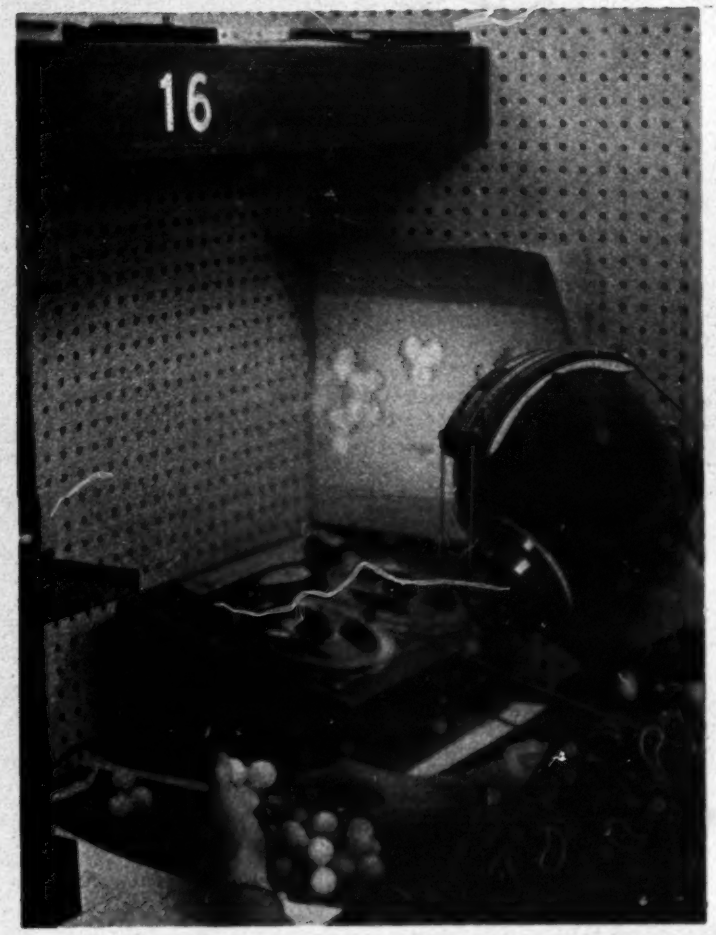
[2]The program also received some support from the College of Agriculture and Natural Resources and the National Science Foundation provided funds for scientific instructional equipment.

Figure 1. A view of the SLATE lab showing the display table (left rear), investigation table (center front), and carrels arranged around the perimeter of the room. Each carrel is equipped with an AV900 Kodak Carousel Projector and a Viking Tape Deck.



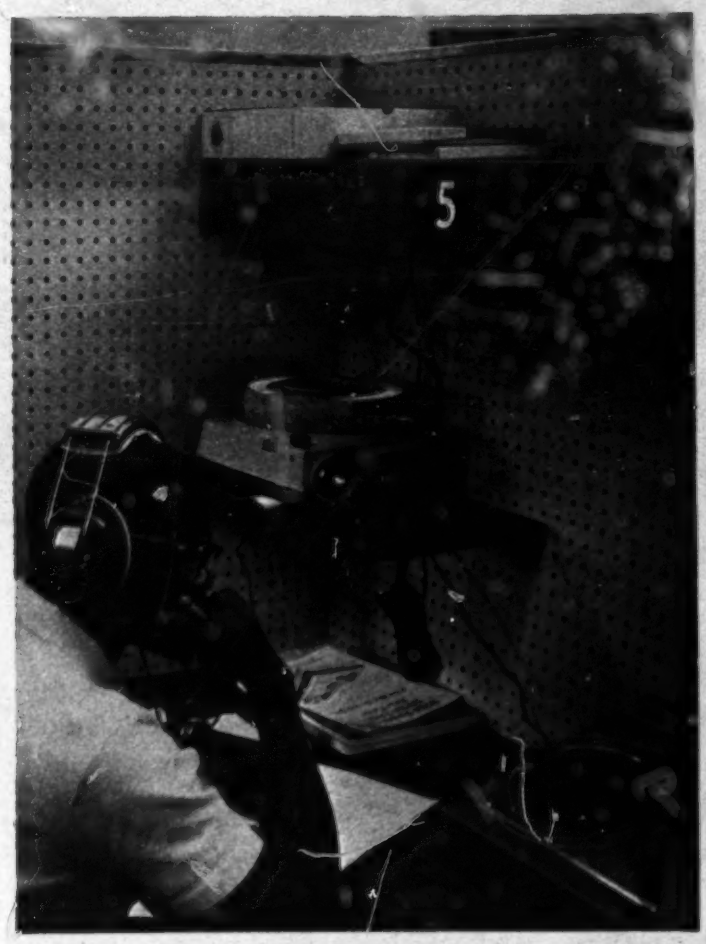


Figure 2. Examples of activities in the SLATE lab: upper left, investigating cation exchange; upper right, observing color of soil horizons; lower left, constructing a model of kaolinite; and, lower right, listening and taking notes of an audio-tutorial.

Table 1

Titles and Sequence of SLATE Units Used in the Spring Term of 1967

Week	SLATE Units
1	1. Concepts of soil and evolution 2. Plant growth and soil utilization
2	3. Texture and structure 4. Bulk density and pore space (aeration)
3	5. Soil moisture tension and plant-soil and water relationships 6. Fallowing, tillage, and temperature
4	7. Chemical and mineralogical properties (Hourly exam in lecture)
5	8. Colloidal fraction 9. Cation exchange capacity
6	10. The big "four" (exchangeable cations) 11. Soil pH
7	(Field trip) (Hourly exam in lecture)
8	12. Soil organisms 13. Organic matter
9	14. Genesis and geography of soils

A workbook has been developed that coordinates all the learning tasks in chronological order for each SLATE unit. (The major headings of the workbook for a particular SLATE unit (Number 5) are presented in Table 2.) After completing the reading assignment and noting the objectives, the student begins the unit in the laboratory with an audio-visual tutorial. After the introduction and a discussion of the first three items, the student is prepared to proceed with an investigation (see Table 2). The audio-visual tutorial discusses the results after the investigation is completed (Item 5.6). An optional investigation near the end of the unit is provided for students especially interested in salt accumulation in soils. The SLATE ends with homework questions and problems and the answers to the questions and problems.

SLATEs are designed to be "self instructional" but an instructor is always in the lab to answer questions and discuss the material.

Materials not suited for study in the carrel are exhibited on the display table. The display table permits students to observe a wide variety of scientific specimens as well as special equipment, photographs, and models.

Ideally, students spend about two hours in the lab and complete a SLATE unit and then return later in the week to complete another unit.

The numbers of the slides are given in parentheses to correspond with the parts of the workbook where they are used. This permits a student to quickly review his notes while making use of the slides without relistening to the tape. The tape time of the audio-visual tutorial is given to help students allocate their time.

The nonscheduled nature of the learning lab program spaces students, so rarely will more than one or two want to make observations at the display table at the same time. This spacing also makes it possible for one or two pieces of most scientific instruments to serve the needs of a large number of students

Table 2

Condensation of the Content of SLATE 5.

Title -- Soil Moisture Tension and Plant-Soil Water Relationships

Preparatory reading assignment

Objectives

Audio-visual tutorial (55 minutes tape time)

5.1 An introduction to SLATE 5
5.2 Water molecules stick together (are polar) (Slides 1-3)
5.3 Attraction of water molecules causes capillarity (Slides 4-6)
5.4 Soil moisture tension can be measured (Slides 7-10)
5.5 Preparation for investigation (Slides 11, 12)

Investigation - A study of water and air content of soils as a function of soil moisture tension

Audio-visual tutorial (continued)

5.6 A discussion of the results of the investigation (Slides 13-15)
5.7 Soils are drained to increase their air content (Slide 16-21)

Display table - Observation of moisture measuring apparatus and drain tile

Audio-visual tutorial (continued)

5.8 Soil moisture coefficients and classification of soil moisture (Slide 22)

5.9 Plant growth as a function of soil moisture tension (Slides 23, 24)

5.10 Irrigation releases soil moisture tension (Slides 25-29)

5.11 Salt in irrigation water acts as brake on water uptake (Slides 30-38)

Optional investigation (determine salt content of soils)

Homework problems and questions

Answers to problems and questions

working at the investigation table. Time consuming operations must be avoided or students will "pile up" and stand in line to use equipment. (The instructor on duty, plays a useful role in making sure the equipment is functioning properly.) Investigations in the programed lab were structured to give the student some experience in discovering knowledge and, hopefully, to shift the motivation for learning away from external rewards and toward intrinsic rewards.

Results - Fall 1966

The SLATE program was first used in the fall of 1966. Enrollment was limited to 76 students. Seventy four students completed the course. Seventy per cent of the students had junior or senior standing. A questionnaire was given at the end of the term and the results are presented in Table 3.

From the students' point of view, they felt they learned a great deal for each hour spent in the course, thought it was one of the most interesting and stimulating science courses they had taken, and frequently thought about the SLATE program outside of class.

Only 18% felt that listening to tapes became tedious. The fact that 37% felt their minds wandered while listening to tapes suggests that more slides should be used along with the tapes and attention given to the length of the tape sequences. They were overwhelmingly in favor of having the lead teacher record the tapes (even though the tapes were considerably less than perfect).

Preparation before beginning the SLATE by reading the appropriate material in the text was believed helpful by 82 per cent of the students. Students are usually not prepared in this way to follow the typical lecture and, thus, an hour spent listening to an audio-tutorial covered more subject matter than is generally covered in an hour of lecture.

Table 3

Results of Questionnaire Given during the Last Lecture in Fall 1966

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1. I felt I learned a lot for each hour spent in this course.	37	51	9	2	2
2. This has been one of the most interesting and stimulating science courses I've had in college.	33	35	18	9	5
3. I frequently found myself thinking about the learning lab program outside of class.	19	56	11	11	2
4. Listening to the tapes became tedious.	0	18	19	54	9
5. I rarely if ever found my mind wandering while listening to the tapes.	5	44	14	32	5
6. A professional speaker (or reader) should be employed to make the tapes.	5	2	12	54	26
7. Reading the preparatory reading assignment before coming to the learning lab was very helpful.	39	53	5	4	0
8. Frequent reference to and use of text was very distracting or objectionable.	4	9	7	61	19
9. The display table for exhibits added little or nothing.	0	4	7	63	26
10. The 3 films used in the Thursday morning group period were a waste of time.	0	5	16	49	28
11. The units had very serious gaps and lack internal continuity.	0	0	12	55	23
12. The repetition within units and between units was very objectionable.	2	11	4	56	28
13. Mechanical failure of tape players and/or slide projectors was not a serious problem.	53	44	0	2	2

This program had the unique advantage that the text and the self-instructional program were written by the author. The text was closely integrated into the program and this resulted in the development of a simpler workbook and used to maximum advantage the pre-class reading preparation before coming to the lab. Frequent reference to tables, figures, and photographs in the text during the audio-visual tutorials did not appear particularly distracting for the students.

The display table in the lab and the movies shown in the lecture period were considered valuable by 79% or more of the students. The units appeared to have had continuity, and were not unnecessarily repetitive. Lastly, about 95% of the students agreed that mechanical failure of players or projectors was not a serious problem.

The students were also permitted to react to a less structured questionnaire that requested written comments. Students particularly liked the freedom of going as fast or as slow as they wanted and they could replay the difficult parts until they had satisfied themselves that they had understood the material. Many had the feeling they learned a great deal by this technique or that they felt they would retain their learning better .

Results - Spring 1967

During most of the spring term, I was acting as a short term education advisor in Argentina. The course was given by Jewell Crabtree, an instructor who had been teaching in the department since the fall of 1964. The enrollment was not limited and nearly three times as many students took the course in the spring term. The program was similar to that in the fall except that 5 SLATE units had been revised during the winter term of 1967.

My voice was on the tape but I remained unknown to the students. During the fall term I had contact with the students each week in a lecture and in a discussion-quiz period. This appeared to make listening to the tapes less tedious and their minds wandered less (see Table 4). They were also more inclined in the spring to want tapes made by a professional speaker. The course in the spring was viewed as being less interesting but students felt they learned a great deal or felt they used their time effectively in both spring and fall terms.

Program Costs

The average cost of the 20 carrel stations is itemized in Table 5 and totals $555.20. This figure represents costs of things and not services. Thus, it includes no costs for recording the master tapes and graphic art or photography. In addition, the cost does not include the scientific equipment and other supplies used in the SLATE lab. Future revisions will result in the use of more 2 X 2 slides and will increase the cost at least $50 per station.

Concluding Comments

A change from the traditional lecture - lab approach to the SLATE approach has been a refreshing experience. Much of this feeling comes from giving the students more responsibility for learning. The teacher-student relationship changes to a more cooperative venture with the teacher's role becoming more one of helping the student learn rather than making the student learn. The student feels, perhaps, that the structured learning lab program produces a more useful learning experience and facilitates memory processing. The emphasis on learning by investigating, I believe, increases the student's interest in the subject and takes the student to a higher level of understanding. During the summer term 1967, I taught Soil Science 430 (Soil Fertility and Fertilizers) with a non-scheduled lab with the help of Dr. John Shickluna. The comments of one student are most pertinent and I

Table 4

Results of Questionnaire Given during the Last Lecture in Spring 1967

	Item	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1.	I learned a great deal in this course.	19	51	18	8	4
2.	This has been one of the most interesting and stimulating science courses I've had in college.	5	26	32	24	13
3.	I frequently found myself thinking about the learning lab program outside of class.	7	35	25	27	6
4.	Listening to the tapes became tedious.	31	30	13	23	2
5.	My mind wandered while listening to tapes.	18	46	15	20	0
6.	A professional speaker (or reader) should be employed to make the tapes.	12	18	19	36	14
7.	The preparatory reading assignments were very helpful.	27	57	10	5	0
8.	Frequent reference to and use of the text was distracting or objectionable.	6	13	14	57	11
9.	The display table for exhibits contributed little to understanding the material.	6	21	20	41	12
10.	The films used in the Thursday morning group period were a waste of time.	6	14	14	43	23
11.	The units had gaps and lack internal continuity.	3	15	30	46	6
12.	Repetition within units and between units was objectionable.	2	9	24	53	11
13.	Mechanical failure of tape players was not a serious problem.	58	34	5	0	4
14.	The taped - illustrated lecture sections of units were too long.	13	28	21	34	4
15.	Self instruction as used in this course results in less efficient use of students time.	8	7	14	42	30
16.	Some of the course content should be handled as a lecture.	17	38	22	18	5
17.	All of the taped portion of a unit should be placed into the first part of the units and all lab work should be grouped together and comprise the second part of the units	7	18	18	33	25
18.	There should be more lab work.	8	20	23	41	8

quote, "I thought the lab was a helpful part of the course. An instructor can stand in front of the room and preach for months on end and a lot of us would really appreciate what he was saying. But, when we are able to perform the tasks ourselves, we remember longer and appreciate more the information we receive." Another Soil Science 430 student commented, "One point which I really enjoyed was the lab which I think is a very useful tool in learning." The favorable comments to the limited SLATE program used for the first time in Soil Science 430 has convinced Dr. Shickluna and myself that the program warrants continued development. It is planned that Soil Science 210 will use the SLATE lab in the fall and spring terms and Soil Science 430 (and perhaps 480) will use the SLATE lab during the winter term.

It appears that successful structured learning and training environments can be developed that produce learning experiences that are more personalized and result in higher quality learning. The time required to develop such programs, however, is enormous. Even so, we may need to find the time if we seriously confront the fact that science is process, not facts. To present a legitimate concept of science as process may require the investigational approach of structured learning and training environments similar to that described in this report.

Table 5

Itemized Average Cost Per Station

Carrel	$116.00
AV900 Kodak Projector	123.50
Viking Tape Deck	118.80
Koss Ear Phones	17.50
Investigation Table (586/20)	29.30
Demonstration Table (280/20)	14.00
Carousel Drums (@ $2.00)	18.00
2 X 2 Slides (362 @ 25¢)	90.50
14 Tapes (@ $1.90)	27.60
	$555.20